MASSACHUSETTS COASTAL COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM MAY-NOVEMBER, 1986

Bruce T. Estrella

and

Daniel J. McKiernan

COMMONWEALTH OF MASSACHUSETTS
Division of Marine Fisheries
Department of Fisheries, Wildlife and
Environmental Law Enforcement
Executive Office of Environmental Affairs
James S. Hoyte, Secretary
July 1, 1987

TABLE OF CONTENTS

PUBLICATION: #14,944-73-109-7-87-CR
Approved by the State Purchasing Agent

ABSTRACT

The sixth consecutive American lobster (Homarus americanus) catch/effort and biological monitoring program was completed in Massachusetts coastal waters in 1986. Six lobstering regions were sampled monthly, during the major lobstering season, May-November. With the cooperation of coastal commercial lobstermen, a total of 40,114 lobster were sampled from 14,799 trap hauls during eighty-two trips aboard commercial lobster vessels.

An improved catch per trap haul set-over-day index was generated by modelling the relationship between catch and immersion time and standardizing effort to our survey modal value of three set-over-days. This new index reduced the variability evident in other catch rate time series which was caused by fluctuating immersion time. The 1986 coastwide mean index for marketable lobster (0.816) was not significantly different from the 1985 index (0.825). Its six-year time series paralleled the landings trend for territorial waters.

Regional exploitation rates and total annual mortality estimates remained high, but stable, during the 1981-1986 period. Lobster within the recruit molt size group comprised 93% of the catch in the inshore regions, and 46% east of Cape Cod where an offshore migrant group dominates catches.

The percentage of females ovigerous increased from 8.6% in 1985 to 9.1% in 1986. Culls also increased from 18.1% to 20.9%, during the same period.

Mean carapace length (81.2 mm), mortality in traps ($< 10\%$), and percentage of males (40.2%) did not differ significantly from 1985 data.

The impact of a hypothetical increase of one mm in minimum legal size was investigated. An analysis based on autumn 1986 size frequency data predicted short-term losses of 5.22% in number and 3.94% in weight. The long-term gain in weight for each succeeding year approximated 0.75%.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This report represents the Massachusetts Division of Marine Fisheries (DMF) sixth annual assessment of the status of the American lobster resource in Massachusetts coastal waters. It was accomplished with data collected through a structured, comprehensive commercial lobster sea sampling effort.

The commercial lobster fishery is the most economically important single-species fishery in Massachusetts coastal waters. Consequently, a long-term coastwide lobster monitoring program which would yield biological as well as catch per unit effort data was devised and initiated in Massachusetts in May, 1981. A sea sampling-survey design was chosen by which both catch per unit effort and biological data could be collected temporally and areally with sufficient precision for stock assessments. The objective was to assess variations in population parameters due to environmental factors, fishing pressure, or the effects of regulatory changes.

Data collected during the 1986 coastwide commercial lobster trap sampling program are summarized below. Parameter trends apparent during the 1981-1986 study period are discussed.

STUDY AREA

The study area is primarily defined by the Massachusetts territorial sea, except where lobstering activities of cooperating commercial lobstermen exceeded territorial boundaries (Figure 1). Territorial waters total 5,322 sq km (2,055 sq n mi), of which an estimated 60% is considered major lobster habitat. Six sampling regions, Cape Ann, Beverly-Salem, Boston Harbor, Cape Cod Bay, outer Cape Cod, and Buzzards Bay were chosen for coverage of the major lobstering regions of the state within resources available. For convenience, these regions are depicted as generalized hatchmarked areas wherein lobster gear sampled may be discontinuously distributed.

SAMPLING PROCEDURE

Sampling of coastal waters was accomplished by monitoring catches during the normal lobstering operations of volunteer commercial lobstermen in each designated region. Multiple lobstering operations were observed to reduce bias from varying degrees of lobstering skill and to enhance areal coverage. Five lobstermen were monitored in the Gulf of Maine regions, three in the outer Cape Cod region, and three in Buzzards Bay. Pot-sampling trips were day trips, conducted a minimum of once per month region (except when manpower limitations precluded effort or cooperating lobstermen were not operating) during the major lobstering season, May-November.

Utilizing portable cassette tape recorders, sea samplers recorded carapace length (to the nearest mm and to the nearest 0.1 mm between 80.5 and 81.0 mm); sex; and condition, including the degree of shell hardness, culls

and other shell damage, external gross pathology, mortality, and presence of extruded ova on females (ovigerous). Catch in number of lobster, number of trap hauls, set-over-days, trap and bait type were also recorded.

ANALYTICAL PROCEDURES

Data were computer coded and keypunched for analysis on the Woods Hole Oceanographic Institution's Digital Equipment Corporation VAX-11/780 computer system. A computer auditing process was used to uncover keypunch and recording errors and statistical analyses were performed with SPSS (Nie 1983) and SAS (SAS Institute 1985) statistical subprograms.

Indices of relative abundance traditionally used to assess the lobster fishery include catch per trap haul (CTHAUL) and catch per trap haul set-over-day (CTHSOD). However, the reliability of these indices depends upon whether certain asumptions are met. Since catch varies with immersion time, CTHAUL is only useful in assessing annual abundance trends if immersion time does not vary considerably. CTHSOD represents an improvement over the CTHAUL index because of its temporal weighting; however, it is unrealistic because catch does not increase in direct proportion to immersion time.

The relationship between catch and immersion time was investigated for American lobster trap fisheries (Auster 1985 ; Fogarty and Borden 1980; Skud 1979; and Thomas 1973). These studies concluded that catch increased with immersion time at a decreasing rate toward an asymptote. This declining fishing efficiency over time is a function of reduced entry due to bait breakdown, trap saturation, escapement, or progressive exploitation of available lobster. Miller (1983) reviewed previous efforts to model this relationship in trap fisheries for other species.

Gulland (1955) derived a nonlinear regression model to describe the relationship between catch and immersion time:

$$C_s = C\infty\ (1 - e^{-Rs})$$

where C_s is the catch on day s, $C\infty$ is the asymptotic catch, and R is the capture rate. Caddy (1977) recommended the use of this model to standardize effort to a common immersion time. Miller (1983) treated it as a widely accepted model.

To establish this relationship for use in our analyses, we used 1985-1986 CPUE data collected from the Cape Ann region. These data were advantageous because they included observations from 6,167 trap hauls, which represented a wide range of immersion times. Also, they were collected from a single lobsterman, which thereby eliminated variability attributable to fishing skill.

Only catch rates for marketable lobster were analyzed. Sublegals were excluded in order to avoid excessive variation in catch rates resulting from escapement through vents, variable vent number, and placement. Data were

partitioned by season: spring (May and June), summer (July, August and September) and autumn (October and November) and the relationship between CTHAUL and immersion time was expressed by Gulland's nonlinear regression model (Figure 2).

We then adopted Sinoda and Kobayasi's (1969) approach:

$$C'_s = C_s(1 - e^{-Rs^*}/1 - e^{-Rs})$$

where C'_s is the adjusted catch at day s, C_s is the empirical catch per trap haul on day s, R is the capture rate and s* is the standard immersion time (model or mean immersion time). The ratio term is an estimate of fishing power and serves as a correction factor for set-over-days.

We then standardized effort to our survey modal value of 3. The catches of traps hauled on a three-day immersion were therefore assigned the immersion time correction factor of 1.0; factors greater than one and less than one were computed for immersion times less than and greater than three days, respectively (Table 1). These improved estimates of fishing power as it relates to immersion time were used to calculate an adjusted CTHSOD index for marketable lobster which we labeled CTH'_3 (CTHAUL standardized to 3 set-over-days).

Estimates of total instantaneous mortality (Z) and total annual mortality ($A = 1 - e^{-Z}$) were computed by each of two methods. The method of Gulland (1969) requires computing the slope of the regression line of numbers at estimated age (15% molt groups) plotted in the natural log. Beverton and Holt's (1956) process employs Von Bertalanffy Growth Equation parameters (K = 0.0634, L = 253 mm; Fair 1977) and mean and minimum length of exploitable sizes:

$$Z = \frac{K(L\infty - \bar{\ell})}{\bar{\ell} - \ell_c}$$

where:

K = growth rate constant
L = asymptotic length
$\bar{\ell}$ = mean length of exploitable sizes
ℓ_c = minimum exploitable size

The Kolmogorov-Smirnov two-sample test and Mann-Whitney U/Wilcoxon W tests were used to determine the significance of year to year variation in parameters.

Because parameter means exhibit significant regional and monthly variation, an areal and temporal data weighting scheme was incorporated into analytical software. Each month's data contribute equally to regional parameter means which are weighted by area in square nautical miles.

Unless specified otherwise, the terms "legal" or "legal sized" lobster include all lobster in the carapace length category $\geq$ 81 mm. The marketable

segment of this category, which excludes ovigerous females, is analyzed separately and is referred to as "marketable lobster". The sublegal length category includes all lobster < 81 mm.

Lobster landings and effort (number of traps fished) data quoted are derived from lobstermen's catch reports which are compiled annually by the DMF Commercial Fisheries Statistics Project.

Since current management strategy stresses uniform coastwide regulations, all data are grouped for a coastwide analysis. However, a number of factors mandate a regional data treatment as well: the uniqueness of the Massachusetts coastline, its role in providing a temperature barrier which profoundly affects many marine species (Colton 1964), and the influence of offshore lobster stocks on the inshore resource.

RESULTS AND DISCUSSION

During the period of May through November, 1986, 82 sampling trips were made aboard commercial lobster vessels in Massachusetts coastal waters. A total of 40,114 lobster were sampled from 14,799 trap hauls.

Abundance

The 1986 coastwide mean CTH'_3 of marketable lobster, 0.816, was not significantly different from the 1985 index, 0.825 (Table 2). A difference of only 1.09% occurred between the annual indices compared to a 7.39% difference between the 1985-86 CTHSOD indices (Table 3). CTHAUL values differed by only 0.12% (Table 4).

The new index reduces the variability in annual indices which is evident in the conventional CTHSOD and CTHAUL time series (Table 5) and tracks the landings trend for territorial waters very well (Figure 3). Its six-year trend is similar to that of CTHAUL because the mean annual immersion times for the 1981-1986 sampling period were similar ranging from 3.3987 to 3.7489. Greater benefits were realized in the smaller regional data sets where annual mean immersion times sometimes differed substantially. Consequently, this analysis is an important adjunct to small scale commercial trap sampling programs in which the mean immersion time sampled is likely to vary annually.

An analysis of the CTH'_3 index for marketable lobster during the six-year study period did not indicate significant differences in the 1981-1983 indices, but a statistically significant decline occurred in 1984 followed by a significant increase to the statistically equal 1985-86 values.

Sublegal lobster catch rates increased in 1986. The CTHSOD index (0.700) was 8% higher than in 1985 (0.647, Table 6). CTHAUL increased by 11% to 1.899 in 1986 (Table 7).

The CTHSOD of all egg-bearing females increased from 0.044 in 1985 to 0.057 in 1986 (Table 8). CTHAUL of "eggers" similarly increased from 0.133

to 0.167 (Table 9). The six-year trend showed 1981 and 1982 values were similar but indices peaked in 1983, declined significantly in 1984 and then significantly increased in 1985 and again in 1986 (Figure 4).

The coastwide percentage of all females ovigerous was significantly higher in 1986 (9.1) than in 1985 (8.6, $P < 0.339$, Table 10). The legal sized index (16.0) increased by 1.0% from 1985 (15.0, Table 11) and the sublegal index (5.6) increased 0.4% (5.2, Table 12).

Despite small changes, as noted above, the annual proportions of female ovigerous during the 1981-1986 study period were very similar within each region. The four Gulf of Maine regional indices were consistently at or below 5% with Cape Ann averaging higher than the other regions. Six year means for outer Cape Cod and Buzzards Bay were 24%.

Exploitation Rate

Estimated exploitation rates remained high (Table 13). Approximately 87-97% of the lobster landed in inshore regions were captured shortly after molting beyond the legal size limit of 81 mm. This index was 46% for the outer Cape Cod region where a large offshore migrant group dominates catches.

No trend in the six year data set was discernible.

Mortality Estimates

Total annual mortality estimates (A) were similar to 1985 estimates ranging from 87% ($Z = 2.03$, Cape Ann) to 98% ($Z = 3.71$, Buzzards Bay) in inshore regions and 40% ($Z = 0.51$) off outer Cape Cod when computed by the method of Gulland (1969, Table 14). Estimates computed by the Beverton and Holt (1956) method ranged from 73% ($Z = 1.32$, Cape Ann) to 91% ($Z = 2.41$, Buzzards Bay) for inshore regions and 42% ($Z = 0.55$) off outer Cape Cod.

Mortality estimates over the six-year study period remained relatively stable.

Estimates of fishing mortality (F) were calculated by a Cohort Analysis procedure (Pope, 1972) which assumes a Von Bertalanffy growth curve. Commercial size frequency data was analyzed by region. Resulting estimates of F plus an assumed natural mortality (M) of 0.15 approximate the Z's calculated by the Beverton and Holt technique.

Weighted average fishing mortality estimates from Cohort Analysis were:

Cape Ann	1.22
Beverly-Salem	1.93
Boston Harbor	1.80
Cape Cod Bay	1.70
Outer Cape Cod	0.47
Buzzards Bay	2.11
Regions combined	1.27

Survey size frequency data (all lobster $\geq$ 81 mm) was expanded on the basis of total landings from commercial lobstermen's catch reports. The population of legal-sized lobster in the territorial sea during the 1986 season was then calculated by Cohort Analysis and estimated to be 15,400,000 (Table 15).

Total mortality rates were relatively stable during the six year study period; however, changes in yield resulting from changes in F can be predicted using $F\Delta t$ values calculated by Cohort Analysis (Jones 1974, Table 16). Results indicate that the current exploitation rates in our coastal regions are so severe that only minimal changes in landings would result from substantial changes in F. The exception is the relatively less exploited outer Cape Cod region.

Carapace Length

The coastwide mean carapace length of all lobster sampled during 1986 was 81.2 mm which was not significantly different from 1985 (81.6 mm, P = 0.168, Table 17). Lobster $\geq$ 81 mm carapace length averaged 90.2 mm (90.1 mm in 1985, Table 18). Marketable lobster averaged 89.3 mm (87.8 mm in 1985, Table 19), and the mean length of sublegal sized lobster was 76.1 mm (76.3 mm in 1985, Table 20).

The inshore regional mean carapace lengths of all lobster ranged from 76.8 mm in the Beverly-Salem region to 81.8 mm off Cape Ann; however, the mean of outer Cape Cod data was 95.0 mm (Table 13). The lobster group in this region is seasonally augmented by the shoalward migration of large offshore lobster. Morrissey (1971) documented the extensive migratory behavior of these lobster. Also, numerous tagged lobster which were released during Maine and Canadian tagging studies in recent years were recaptured in this region. Some offshore influence on Cape Ann lobster is also discernible. Size frequency analysis reveals that the percentage of lobster $\geq$ 100 mm was greatest in Cape Ann and Outer Cape Cod regions (Tables 21-27).

Additional evidence of infiltration of migrating lobster from outside Massachusetts territorial waters may be found in reports of lobster marked with V-shaped notches in their uropods. These lobster are presumed to have migrated from Maine waters where a V-notched female protection program is enforced.

During 1984-1986 commercial lobster trap sampling efforts off Cape Ann, 3.4%, 3.3%, and 2.2% of the legal sized females were reported as V-notched for the three years, respectively. Observations in the Outer Cape Cod region totalled 3.1%, 5.8%, and 6.2% for the same time period. All other Massachusetts inshore regions sampled exhibited low percentages (0 - 0.8). These V-notched females were generally large, averaging greater than 100 mm in carapace length.

The 1986 coastwide mean carapace length of all ovigerous females was 88.1 mm which was not significantly different from the 1985 mean (87.9, P = 0.2143, Table 28). The mean sizes of "eggers" in the Beverly-Salem,

Boston Harbor, and Cape Cod Bay regions were similar (83.5, 81.3, and 86.8) compared to the relatively high means of 95.0 and 107.3 mm for Cape Ann and outer Cape Cod, respectively. Buzzards Bay ovigerous females averaged lowest at 79.4 mm.

The mean size of ovigerous females is a function of the size at maturity and exploitation rates in the respective regions (Estrella and McKiernan 1986).

The coastwide proportion of ovigerous female American lobster in the legal size category was 53.8%, which declined from 57.7% in 1985 (Table 29). All regional indices also declined.

Gauge Increase Assessment

A bill is currently being discussed by the legislature which, if passed, will provide a five-year program for increasing the minimum legal size for American lobster from 3 3/16" to 3 5/16". Increases of 1/32" would be effected during years 1, 2, 4, and 5 with no increase during year 3.

Impact assessments of each of these increases is difficult at this time due to the narrow increment of carapace length increase which is proposed. Also, existing commercial length frequency data is in millimeters and 1/32" equals only 0.79375 mm. An assessment of a one millimeter increase would therefore represent an overestimate of impact.

Nevertheless, a preliminary analysis of an increase in minimum size from 81 mm to 82 mm was accomplished with the Hancock method (Hancock 1975). All data from 1986 commercial lobster sea sampling were analyzed by region and regions combined to predict short-term losses and long-term gains. However, seasonal fluctuations in size distribution occur as a result of fishing mortality and recruitment from molting. Consequently, analyses were repeated with November data only to determine if analyzing combined May-November data biased results.

The analysis of all 1986 data predicted a coastwide short-term loss of 7.72% in lobster number and 6.93% in lobster weight followed by a long-term gain of 1.0 - 1.2% in weight (depending upon the fishing mortality estimate used) for each year thereafter (Table 30).

Predicted losses based on the analysis of November, 1986 data were less for all regions with a coastwide short-term loss of 5.22% in number and 3.94% in weight (Table 31). The long-term predicted gain in weight for each succeeding year ranged from 0.7 - 0.8%.

Gauge increase assessments based on data collected as close as possible to the implementation of the new gauge size may yield the most accurate results.

Sex Ratio

Males were again outnumbered by females in 1986 survey catches. Of all lobster sampled, 40.2% were males, which was not significantly different from the 1985 proportion (41.9, P = 0.9223, Table 32). All regional rates except that for the Beverly-Salem region declined in 1986. Legal and sublegal size categories exhibited similar trends (Tables 33 and 34).

A majority of females in the catches can be attributed to protection of egg-bearing females, reduced growth rate of sexually mature females, and enhanced trap retention of females due to their broader shell dimensions.

Culls

The percentage of culls among all lobster sampled during 1986 was 20.9% (Table 35). This represented a significant increase from 1985 (18.1%, $P < 0.001$). Most regional indices also increased from the previous year. Legal, marketable, and sublegal size categories exhibited similar increases (Tables 36-38).

The six year trend depicted an escalated number of culls in all regions with Buzzards Bay remaining relatively stable. Until 1984, Buzzards Bay exhibited the highest cull rate which was possibly related to its high exploitation rate (highest among coastal Massachusetts regions). In 1984, most regions' cull rates increased substantially while the Buzzards Bay rate remained unchanged.

This escalating cull rate probably reflected increased fishing effort throughout coastal waters by both mobile and fixed gear (Buzzards Bay is closed to trawling). Commercial traps fished inside 69 W 41 N increased from a reported total 299,368 in 1981 to 408,654 in 1986. The larger number of traps fished confined more lobster in small compartments with other aggressive predators (lobster or finfish). These aggressive encounters are enhanced in wire traps which reduce escapement of sublegal lobster. In addition, these traps have a reputation for causing culls because lobster are more difficult to remove when they grasp the wire strands. The increased use of traps (wood or wire) is a plausible explanation for much of the increased cull rate, especially in nearshore waters where other fishing activities such as trawling or gillnetting are minimal.

Nevertheless, we have detected extraordinarily high cull rates during certain months in the Cape Ann region which may be caused by fishing activities other than pot fishing. The traps sampled in this region were moved east to deeper water ($\geq$ 120 ft contour) in the autumn. Cull rates of 49% and 53% were subsequently observed during October and November, respectively, in contrast to rates of 9 to 25% during May-September in shoaler waters. The higher incidence appears to be a function of the area fished rather than seasonality. This area is open to trawling by special permit only from February 1 - March 31 and from June 15 - September 30.

Several studies documented enhanced shell damage and cull rate from bottom trawl activity particularly during the molt period (Currier 1984, Ganz 1980, Smith et al. 1985). However, the effect of gillnetting on lobster cull rates needs to be investigated.

Trap Mortality

Percent trap mortality for all lobster sampled during 1986 was 0.20 which did not differ significantly from the 1985 value (0.18, P = 0.3027, Table 39). Indices for legal and sublegal size groups were also less than one percent (Tables 40-41). Although this parameter value may vary seasonally and can be enhanced by environmental stresses, molting, intra- and interspecific aggression during entrapment, pollution, or the synergistic affect of these factors, the six year trend indicates that trap mortality is consistently low and does not represent a problem to this fishery.

ACKNOWLEDGEMENTS

We are indebted to the many commercial lobstermen who are involved in this cooperative lobster resource monitoring effort. The success of this program is due primarily to their continued interest and cooperation. Unfortunately, we must refrain from naming them in order to protect the confidentiality of their catch information. Gratitude is also extended to Brian Kelly and Vincent Malkoski of the Pilgrim Power Plant Project (funded by Boston Edison Company) and Peter Hoar who assisted in data collection; James Fair who administered the project and reviewed the manuscript; Ann-Marie Schultz who supplied word processing assistance during the report drafting stage; and Carleen Mackin who typed the manuscript. Automatic data processing, including data entry, was supported by the National Marine Fisheries Service (NMFS) Northeast Fisheries Center, Woods Hole, MA. Computer programming and analytical advice were provided by Joseph Idoine and Michael J. Fogarty of NMFS, and personnel at the Information Processing Center Laboratory, Woods Hole Oceanographic Institution, Woods Hole, MA.

LITERATURE CITED

Auster, P. J. 1985. Factors affecting catch of American lobster, Homarus americanus in baited traps. NOAA NURP Program/University of Connecticut Sea Grant, CT-SG-85-1, 46 p.

Beverton, R. J. H. and S. J. Holt. 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapports et Proces-Verbaux des Reunions 140: 67-83.

Caddy, J. D. 1977. Some considerations underlying definitions of catchability and fishing effort in shellfish fisheries, and their relevance for stock assessment purposes. Int. Cons. Explor. Mer, Shellfish and Benthos Committee, C.M. 1977/K:18, 21 p.

Colton, J. B. 1964. History of oceanography in the offshore waters of the Gulf of Maine. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries No. 496, 1-18.

Currier, T. P. 1984. Research trawl-induced lobster damage. Massachusetts Division of Marine Fisheries News, November-December, 3p.

Estrella, B. T. and D. J. McKiernan. 1986. Massachusetts coastal commercial lobster trap sampling program, May-November, 1985. Massachusetts Division of Marine Fisheries, 74 p.

Fair, J. J., Jr. 1977. Lobster investigations in management area I: southern Gulf of Maine. NOAA, NMFS State-Federal Relationships Div., Mass. Lobster Report No. 8, April 21, 1975 - April 20, 1977, 8 p. and Appendix, 14 p.

Fogarty, M. J. and D. V. D. Borden. 1980. Effects of trap venting on gear selectivity in the inshore Rhode Island American lobster, Homarus americanus, fishery. Fishery Bulletin, U.S., 77(4):925-933.

Ganz, A. 1980. Otter trawl induced lobster (Homarus americanus) damage evaluation. Final report 04-7-043-44041, Rhode Island Division of Fish and Wildlife, Wickford, R.I. 23 p.

Gulland, J. A. 1955. Estimation of growth and mortality in commercial fish populations. Fish Invest. Minist. Agric. Fish. Food, Ser. II, 18(9): 1-46.

Gulland, J. A. 1969. Manual methods of fish stock assessment. Manuals in Fisheries Science No. 4.

Hancock, D. A. 1975. The Yorkshire fishery for edible crabs (Cancer pagurus): assessment of changes in the minimum legal size. Fishery Investigations, Series II, Marine Fisheries Great Britain Ministry of Agriculture Fisheries and Food 27(8).

Jones, R. 1974. Assessing the long term effects of changes in fishing effort and mesh size from length composition data. ICES CM 1974/F:33.

Miller, R. J. 1983. How many traps should a fisherman fish? North American Journal of Fisheries Management. 3(1) 1-8.

Morrissey, T. D. 1971. Movement of tagged American lobster, Homarus americanus, liberated off Cape Cod, Massachusetts. Transactions American Fisheries Society, 100(1):117-120.

Nie, N. H. 1983. SPSS: statistical package for the social sciences, McGraw-Hill, New York.

Pope, J. G. 1972. An investigation of the accuracy of virtual population analysis using Cohort Analysis. Research Bulletin int. Comm. NW Atlant. Fish; (9):65-74.

SAS Institute, 1985. SAS user's guide: statistics, Version 5 Edition. SAS Institute, Inc., CARY, NC.

Sinoda, M. and T. Kobayasi. 1969. Studies on the fishery of zuwai crab in the Japan sea. VI. Efficiency of the toyama kago in capturing the beni-zuwai crab. Bull. Jpn. Soc. Sci. Fish. 35:948-956.

Skud, B. E. 1979. Soak time and the catch per pot in an offshore fishery for lobsters, Homarus americanus. Pages 190-196 in H. J. Thomas, ed. Population assessments of shellfish stocks. Rapp. P. V. Reun. Cons. Int. Explor. Mer. 175:190-196.

Smith, E. M. 1985. A study of lobster fisheries in the Connecticut waters of Long Island Sound with special reference to the effects of trawling on lobsters. Connecticut Department of Environmental Protection, Marine Fisheries Program. 1-45.

Thomas, J. C. 1973. An analysis of the commercial lobster, Homarus americanus, fishery along the coast of Maine, August 1966 through December 1970. NOAA Tech. Rep. NMFS SSRF-667. 57 pp.

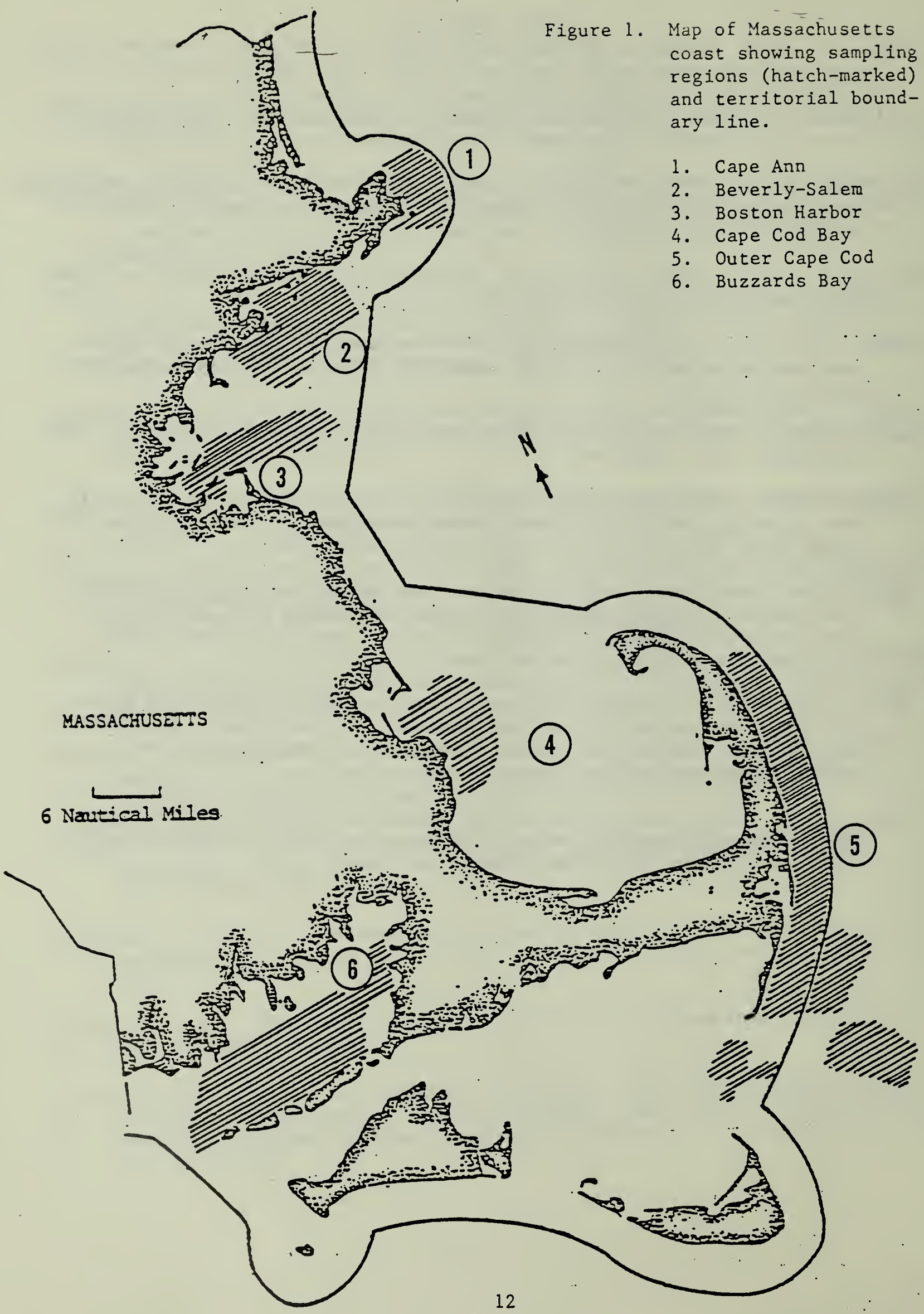

Figure 1. Map of Massachusetts coast showing sampling regions (hatch-marked) and territorial boundary line.

1. Cape Ann
2. Beverly-Salem
3. Boston Harbor
4. Cape Cod Bay
5. Outer Cape Cod
6. Buzzards Bay

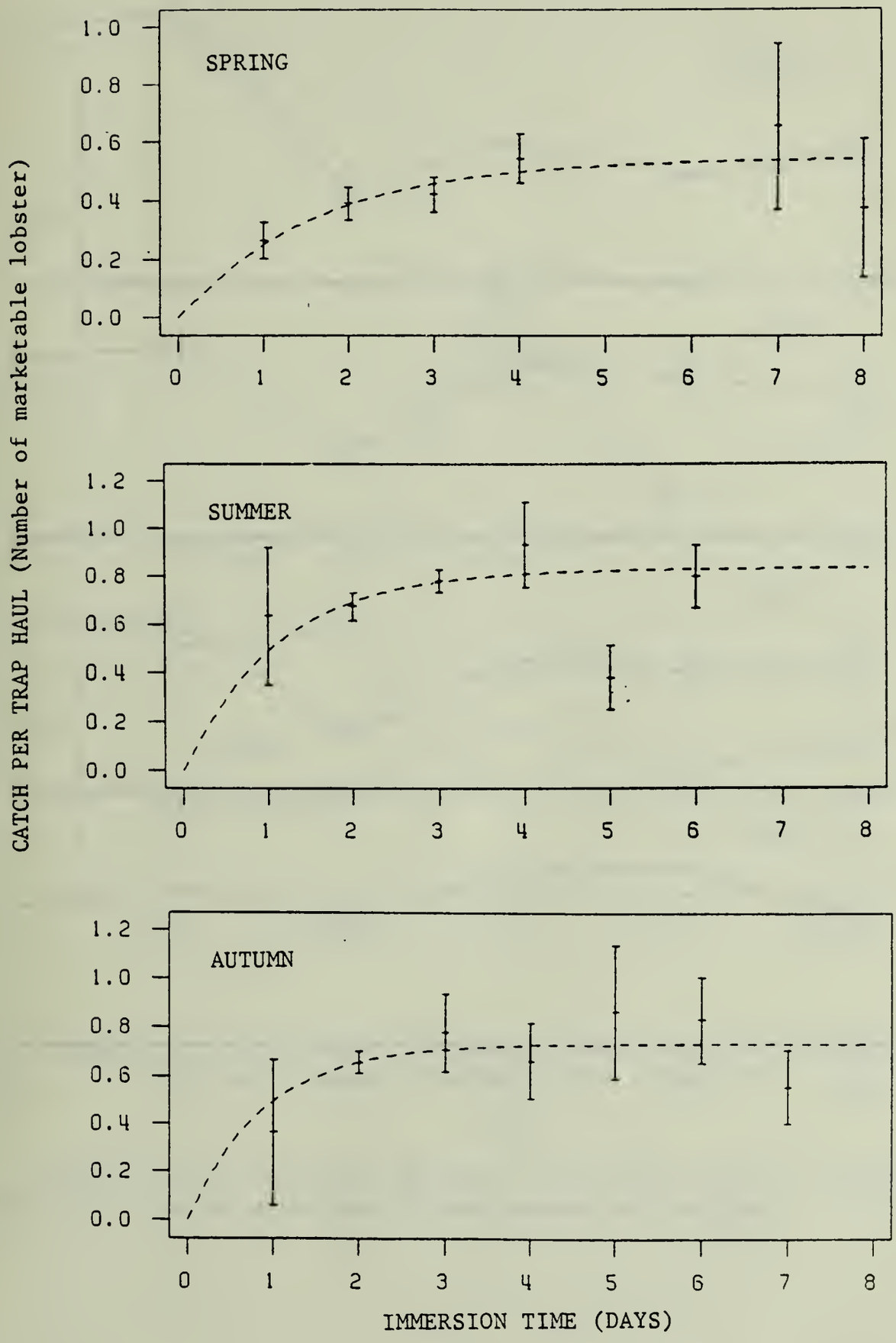

Figure 2. Relationship between predicted CTHAUL and immersion time (dashed line) with observed CTHAUL means and 95% confidence intervals.

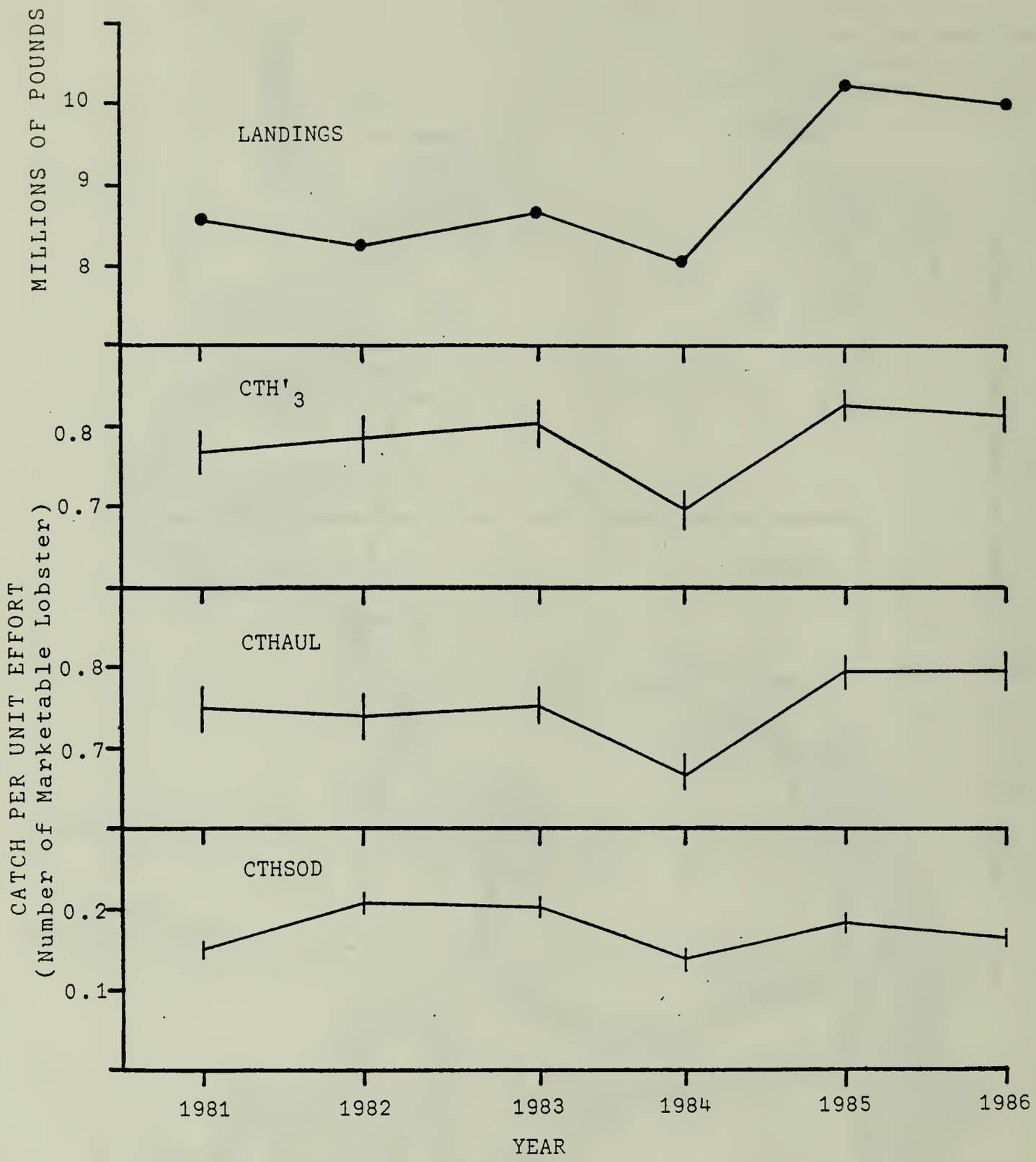

Figure 3. Commercial lobster landings and catch per unit effort indices from Massachusetts territorial waters, 1981-1986.

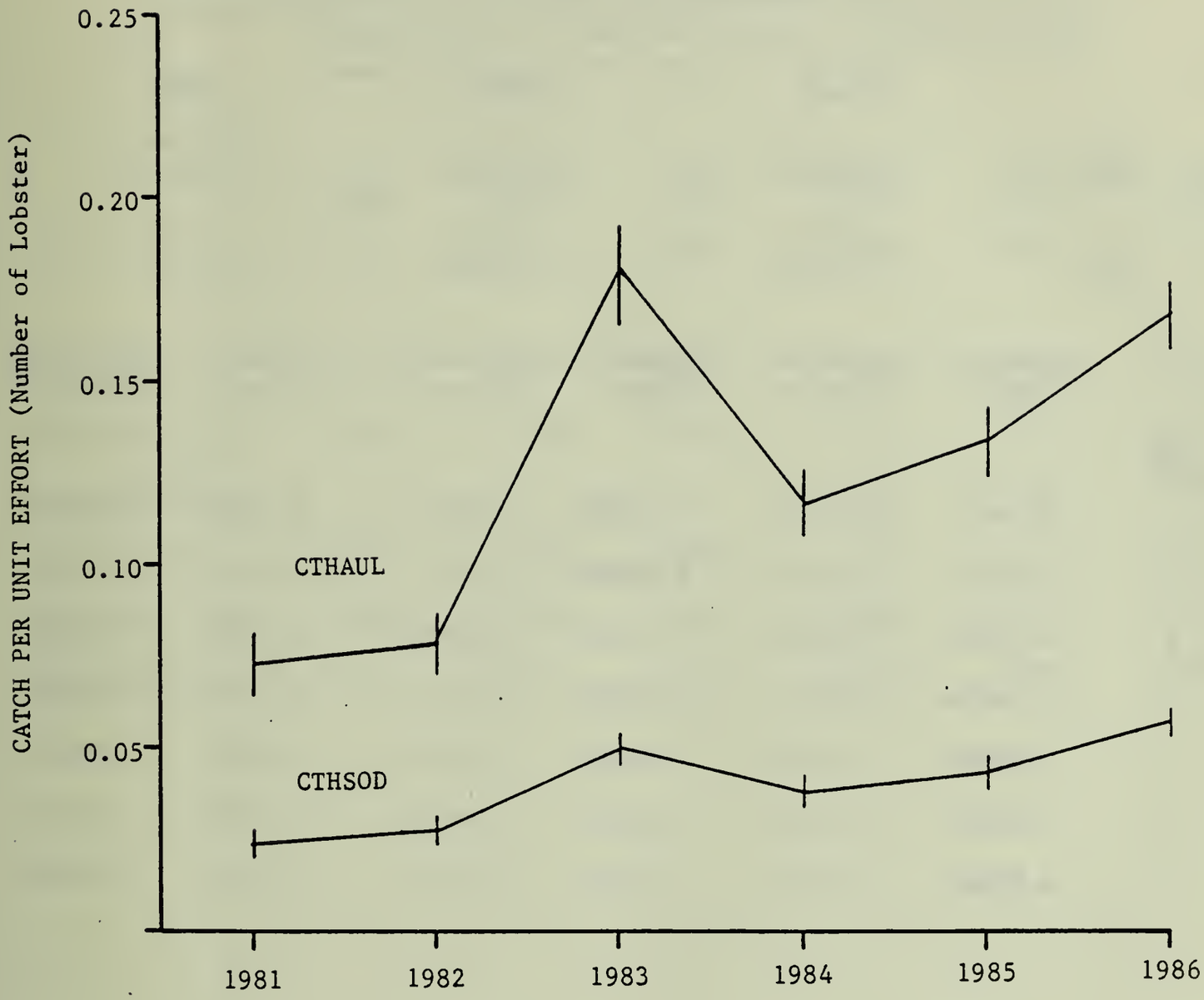

Figure 4. Catch rate of ovigerous female American lobster from Massachusetts coastal waters, 1981-1986.

Table 1. Seasonal estimates of regression model coefficients, predicted CTHAUL, and soak time correction factors for Massachusetts commercial lobster data.

	Spring	Summer	Fall
C_∞	0.54602	0.83002	0.73470
(SE)	(0.05424)	(0.04406)	(0.04646)
R	0.60831	0.88977	1.11799
(SE)	(0.15038)	(0.19040)	(0.30781)

	Predicted CTHAUL	Correction Factors	Predicted CTHAUL	Correction Factors	Predicted CTHAUL	Correction Factors
Day						
1	0.24883	0.54333	0.49809	0.63313	0.49450	0.69744
2	0.38427	0.83905	0.68998	0.89318	0.65617	0.92545
3	0.45798	1.00000	0.77250	1.00000	0.70903	1.00000
4	0.498101	1.08760	0.80639	1.04388	0.72630	1.02437
5	0.51994	1.13528	0.82032	1.06190	0.73196	1.03243
6	0.53182	1.16123	0.82603	1.06930	0.73380	1.03495
7	0.53829	1.17536	0.82838	1.07234	0.73441	1.03580

Table 2. CTH'_3 by state and region for all marketable lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.767	0.785	0.803	0.696	0.825	0.816
Cape Ann	0.732	0.808	0.624	0.663	0.634	0.699
Beverly-Salem	0.934	0.898	0.881	0.835	0.663	0.496
Boston Harbor	--	--	--	1.108	1.254	1.096
Cape Cod Bay	0.710	0.776	0.680	0.479	0.716	0.822
Outer Cape Cod	0.808	0.824	0.765	0.598	0.856	0.811
Buzzards Bay	0.611	0.571	1.110	0.870	0.953	0.907

Table 3. CTHSOD by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.249	0.309	0.302	0.238	0.284	0.263
Cape Ann	0.181	0.349	0.304	0.289	0.238	0.267
Beverly-Salem	0.305	0.368	0.397	0.291	0.197	0.146
Boston Harbor	--	--	--	0.362	0.467	0.367
Cape Cod Bay	0.287	0.364	0.285	0.178	0.280	0.275
Outer Cape Cod	0.125	0.146	0.138	0.113	0.180	0.130
Buzzards Bay	0.202	0.190	0.320	0.314	0.327	0.356

Table 4. CTHAUL by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.747	0.740	0.753	0.668	0.796	0.795
Cape Ann	0.759	0.723	0.504	0.578	0.596	0.660
Beverly-Salem	0.884	0.857	0.793	0.780	0.661	0.494
Boston Harbor	--	--	--	1.107	1.181	1.071
Cape Cod Bay	0.658	0.677	0.617	0.446	0.666	0.797
Outer Cape Cod	0.887	0.896	0.811	0.650	0.896	0.859
Buzzards Bay	0.610	0.578	1.116	0.821	0.938	0.835

Table 5. Annual percent change in commercial lobster landings and catch rates of marketable lobster from Massachusetts territorial waters, 1981-1986.

	1981-82	1982-83	1983-84	1984-85	1985-86
Landings	-3.37	+4.97	-7.34	+27.36	-2.55
CTH'_3	+2.35	+2.29	-13.30	+18.53	-1.09
CTHSOD	+24.10	-2.26	-21.19	+19.33	-7.39
CTHAUL	-0.94	+1.76	-11.29	+19.16	-0.12

Table 6. CTHSOD by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.580	0.672	0.718	0.521	0.647	0.700
Cape Ann	0.067	0.109	0.586	0.450	0.395	0.474
Beverly-Salem	0.708	0.711	1.263	0.948	0.833	0.801
Boston Harbor	--	--	--	0.901	1.162	1.138
Cape Cod Bay	0.710	1.013	0.639	0.322	0.594	0.551
Outer Cape Cod	0.037	0.024	0.383	0.033	0.035	0.027
Buzzards Bay	0.787	0.620	0.638	0.785	0.848	1.312

Table 7. CTHAUL by state and region for all American lobster < 81 mm sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	1.473	1.401	1.624	1.389	1.705	1.899
Cape Ann	0.256	0.199	1.044	0.909	1.031	1.126
Beverly-Salem	1.855	1.713	2.526	2.504	2.567	2.435
Boston Harbor	--	--	--	2.773	3.038	3.314
Cape Cod Bay	1.544	1.680	1.345	0.825	1.337	1.512
Outer Cape Cod	0.233	0.145	0.210	0.189	0.160	0.161
Buzzards Bay	2.381	1.916	2.316	1.965	2.452	3.118

Table 8. CTHSOD by state and region for all ovigerous female American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.024	0.027	0.050	0.038	0.044	0.057
Cape Ann	0.002	0.011	0.024	0.015	0.016	0.017
Beverly-Salem	0.011	0.009	0.008	0.003	0.011	0.004
Boston Harbor	--	--	--	0.009	0.007	0.015
Cape Cod Bay	0.020	0.025	0.016	0.009	0.015	0.010
Outer Cape Cod	0.012	0.028	0.040	0.030	0.038	0.032
Buzzards Bay	0.079	0.053	0.230	0.183	0.193	0.297

Table 9. CTHAUL by state and region for all ovigerous female American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.073	0.078	0.179	0.116	0.133	0.167
Cape Ann	0.010	0.016	0.038	0.027	0.039	0.047
Beverly-Salem	0.025	0.033	0.016	0.006	0.033	0.018
Boston Harbor	--	--	--	0.030	0.025	0.050
Cape Cod Bay	0.048	0.048	0.040	0.024	0.040	0.031
Outer Cape Cod	0.081	0.178	0.242	0.170	0.176	0.225
Buzzards Bay	0.243	0.139	0.828	0.515	0.555	0.748

Table 10. Percent of females ovigerous by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	5.9	7.7	10.9	9.1	8.6	9.1
Cape Ann	1.7	3.1	4.4	3.2	4.6	5.0
Beverly-Salem	1.7	2.8	1.2	0.4	1.9	1.1
Boston Harbor	--	--	--	1.4	1.2	2.0
Cape Cod Bay	3.9	3.1	3.7	3.1	3.2	2.1
Outer Cape Cod	11.1	23.0	30.3	26.8	22.3	28.9
Buzzards Bay	16.0	16.9	32.5	26.6	25.0	25.3

Table 11. Percent of females ovigerous by state and region for all American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	8.5	13.3	18.9	16.2	15.0	16.0
Cape Ann	2.5	3.7	9.6	6.3	9.5	10.6
Beverly-Salem	2.8	6.3	2.9	1.1	4.8	3.2
Boston Harbor	--	--	--	3.2	2.4	3.0
Cape Cod Bay	8.0	5.9	7.0	5.5	6.5	3.1
Outer Cape Cod	12.9	25.6	34.5	32.2	25.6	33.2
Buzzards Bay	17.0	24.6	30.0	28.5	26.6	23.7

Table 12. Percent of females ovigerous by state and region for American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	4.3	4.1	6.4	5.1	5.2	5.6
Cape Ann	0.0	1.6	1.3	1.2	1.8	1.7
Beverly-Salem	1.3	1.5	0.7	0.3	1.1	0.7
Boston Harbor	--	--	--	0.7	0.8	1.7
Cape Cod Bay	2.2	2.2	2.4	2.0	1.9	1.7
Outer Cape Cod	0.0	2.1	1.0	1.4	0.4	1.8
Buzzards Bay	15.7	14.2	34.0	25.5	24.3	25.9

Table 13. Estimated exploitation rates by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	86	86	86	86	88	88
Cape Ann	91	92	87	89	87	87
Beverly-Salem	89	92	94	88	96	96
Boston Harbor	--	--	--	94	94	96
Cape Cod Bay	90	93	92	94	93	94
Outer Cape Cod	46	43	42	38	48	46
Buzzards Bay	98	96	96	94	96	97

Table 14. Total instantaneous (Z)* and total annual (A)** mortality estimates of American lobster by region, Massachusetts coastal waters, 1981-1986.

	1981		1982		1983		1984		1985		1986	
	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)
Cape Ann	1.65* 81%**	1.32 73%	2.18 89%	1.39 75%	1.72 82%	1.35 74%	1.92 85%	1.52 78%	1.94 86%	1.33 74%	2.03 87%	1.32 73%
Beverly-Salem	1.97 86%	1.59 80%	2.15 88%	1.70 82%	2.41 91%	1.85 84%	2.71 93%	1.78 83%	3.64 97%	1.96 86%	3.60 97%	1.99 86%
Boston Harbor							2.52 92%	1.82 84%	3.59 97%	1.75 83%	2.60 93%	1.92 85%
Cape Cod Bay	2.53 92%	1.64 81%	2.69 93%	1.92 85%	2.42 91%	1.72 82%	2.52 92%	2.07 87%	2.31 90%	1.88 85%	2.83 94%	1.92 85%
Outer Cape Cod	0.43 35%	0.54 42%	0.46 37%	0.55 42%	0.42 34%	0.53 41%	0.33 28%	0.52 41%	0.52 41%	0.57 43%	0.51 40%	0.55 42%
Buzzards Bay	3.02 95%	2.97 95%	3.00 95%	2.53 92%	8.64 99%	2.26 90%	3.14 96%	2.21 89%	3.55 97%	2.36 91%	3.71 98%	2.41 91%
Regions combined	1.27 72%	1.07 66%	1.36 74%	1.12 67%	1.32 73%	1.10 67%	1.29 72%	1.15 68%	1.36 74%	1.13 68%	1.36 74%	1.12 67%

Table 15. Cohort analysis of 1986 American lobster size frequency data expanded to total Massachusetts landings.

LENGTH GROUP	NUMBER LANDED	NUMBER IN SEA	MEAN NUMBER	F/Z	ZDT	FDT	Z	DT	F
166.0——171.0	0.503E+03	0.640E+03							
161.0——166.0	0.545E+03	0.131E+04	0.937E+03	0.810	0.718	0.582	0.790	0.909	0.640
156.0——161.0	0.152E+04	0.310E+04	0.208E+04	0.847	0.859	0.728	0.982	0.875	0.832
151.0——156.0	0.124E+04	0.481E+04	0.389E+04	0.727	0.439	0.319	0.549	0.801	0.399
146.0——151.0	0.223E+04	0.775E+04	0.617E+04	0.760	0.477	0.362	0.624	0.764	0.474
141.0——146.0	0.299E+04	0.118E+05	0.963E+04	0.740	0.419	0.310	0.577	0.727	0.427
136.0——141.0	0.642E+04	0.198E+05	0.155E+05	0.798	0.520	0.415	0.743	0.700	0.593
131.0——136.0	0.108E+05	0.333E+05	0.260E+05	0.806	0.518	0.417	0.772	0.671	0.622
126.0——131.0	0.274E+05	0.653E+05	0.475E+05	0.855	0.674	0.576	1.032	0.652	0.882
121.0——126.0	0.303E+05	0.103E+06	0.828E+05	0.798	0.458	0.366	0.743	0.617	0.593
116.0——121.0	0.468E+05	0.162E+06	0.130E+06	0.801	0.448	0.359	0.755	0.594	0.605
111.0——116.0	0.778E+05	0.257E+06	0.206E+06	0.815	0.464	0.378	0.810	0.573	0.660
106.0——111.0	0.139E+06	0.424E+06	0.334E+06	0.834	0.500	0.417	0.902	0.555	0.752
101.0——106.0	0.244E+06	0.713E+06	0.556E+06	0.845	0.520	0.439	0.969	0.537	0.819
96.0——101.0	0.254E+06	0.103E+07	0.864E+06	0.792	0.371	0.294	0.722	0.515	0.572
91.0—— 96.0	0.118E+07	0.233E+07	0.160E+07	0.905	0.814	0.736	1.572	0.518	1.422
86.0—— 91.0	0.309E+07	0.571E+07	0.377E+07	0.915	0.895	0.819	1.764	0.507	1.614
81.0—— 86.0	0.401E+07	0.103E+08	0.777E+07	0.878	0.587	0.516	1.233	0.476	1.083
TOTAL	0.912E+07		0.154E+08				WTD. AVE. F:		1.271

Table 16. Prediction of the effect on landings of changes in fishing mortality (F), Massachusetts coastal waters, 1986.

	Percent Change in F									
	-50	-40	-30	-20	-10	+10	+20	+30	+40	+50
Cape Ann	7.24	7.20	4.58	2.91	1.38	-1.31	-2.44	-3.53	-4.40	-5.45
Beverly-Salem	8.27	7.10	5.43	3.58	1.79	-1.60	-3.33	-4.69	-5.99	-7.22
Boston Harbor	3.88	4.63	4.09	2.95	1.48	-1.51	-2.99	-4.36	-5.70	-6.83
Cape Cod Bay	9.86	7.87	5.69	3.61	1.71	-1.56	-2.99	-4.39	-5.60	-6.75
Outer Cape Cod	21.87	17.06	12.11	7.51	3.45	-3.04	-5.42	-7.40	-9.04	-10.54
Buzzards Bay	7.62	7.00	5.55	3.78	1.92	-1.81	-3.64	-5.18	-6.73	-8.29

Table 17. Mean carapace length (mm) by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	81.7	82.1	81.7	81.7	81.6	81.2
Cape Ann	86.2	86.2	82.1	81.7	82.1	81.8
Beverly-Salem	78.2	80.0	77.9	78.3	78.2	76.8
Boston Harbor	--	--	--	79.8	79.2	79.1
Cape Cod Bay	80.0	79.5	80.0	79.3	79.6	79.7
Outer Cape Cod	95.5	96.0	95.9	96.5	95.1	95.0
Buzzards Bay	77.8	78.1	80.1	79.6	78.9	78.4

Table 18. Mean carapace length (mm) by state and region for all American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	90.6	90.2	90.4	90.5	90.1	90.2
Cape Ann	88.9	88.5	88.7	88.2	88.8	88.9
Beverly-Salem	87.6	87.2	86.7	86.9	86.4	86.3
Boston Harbor	--	--	--	86.9	87.0	86.5
Cape Cod Bay	87.4	86.5	87.1	86.2	86.6	86.5
Outer Cape Cod	99.1	98.9	99.5	101.1	98.2	98.7
Buzzards Bay	84.6	85.2	85.7	85.9	85.5	85.4

Table 19. Mean carapace length (mm) by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	90.2	89.7	89.7	90.0	87.8	89.3
Cape Ann	88.6	88.3	88.3	87.9	88.4	88.3
Beverly-Salem	87.6	87.0	86.6	86.9	86.2	86.2
Boston Harbor	--	--	--	86.8	86.9	86.4
Cape Cod Bay	87.2	86.4	86.9	86.1	86.4	86.3
Outer Cape Cod	98.2	97.5	97.4	99.7	97.0	96.3
Buzzards Bay	84.7	85.2	85.7	85.8	85.2	85.3

Table 20. Mean carapace length (mm) by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	75.8	76.3	76.2	76.1	76.3	76.1
Cape Ann	78.0	77.7	77.5	77.3	77.6	77.1
Beverly-Salem	74.3	76.5	74.9	76.1	75.9	74.7
Boston Harbor	--	--	--	77.1	76.9	76.9
Cape Cod Bay	76.6	76.4	76.7	75.6	76.1	76.2
Outer Cape Cod	75.9	76.2	77.1	75.1	76.6	75.9
Buzzards Bay	75.8	75.5	76.8	76.4	76.1	76.0

Table 21. Frequency of carapace length observations by number, percent, and cumulative percent for all lobster sampled, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
29	3	0.0	0.0
30	1	0.0	0.0
32	1	0.0	0.0
34	0	0.0	0.0
35	1	0.0	0.0
36	1	0.0	0.0
37	5	0.0	0.0
38	2	0.0	0.0
40	3	0.0	0.0
41	12	0.0	0.1
42	6	0.0	0.1
43	2	0.0	0.1
44	2	0.0	0.1
45	6	0.0	0.1
46	17	0.0	0.2
47	6	0.0	0.2
48	4	0.0	0.2
49	4	0.0	0.2
50	9	0.0	0.2
51	12	0.0	0.2
52	28	0.1	0.3
53	32	0.1	0.4
54	41	0.1	0.5
55	51	0.1	0.6
56	60	0.1	0.8
57	56	0.1	0.9
58	55	0.1	1.0
59	69	0.2	1.2
60	92	0.2	1.4
61	106	0.3	1.7
62	107	0.3	2.0
63	135	0.3	2.3
64	131	0.3	2.6
65	180	0.4	3.1
66	178	0.4	3.5
67	241	0.6	4.1
68	296	0.7	4.9
69	306	0.8	5.6
70	445	1.1	6.7

Table 21 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
71	471	1.2	7.9
72	634	1.6	9.5
73	791	2.0	11.5
74	1149	2.9	14.3
75	1636	4.1	18.4
76	2284	5.7	24.1
77	2899	7.2	31.3
78	3432	8.6	39.9
79	3775	9.4	49.3
80	5710	14.2	63.5
81	1129	2.8	66.3
82	1130	2.8	69.2
83	1131	2.8	72.0
84	979	2.4	74.4
85	1072	2.7	77.1
86	1080	2.7	79.8
87	950	2.4	82.2
88	962	2.4	84.6
89	863	2.2	86.7
90	770	1.9	88.6
91	634	1.6	90.2
92	523	1.3	91.5
93	405	1.0	92.5
94	286	0.7	93.2
95	224	0.6	93.8
96	156	0.4	94.2
97	160	0.4	94.6
98	108	0.3	94.9
99	127	0.3	95.2
100	96	0.2	95.4
101	126	0.3	95.7
102	129	0.3	96.0
103	138	0.3	96.4
104	122	0.3	96.7
105	97	0.2	96.9
106	77	0.2	97.1
107	95	0.2	97.4
108	85	0.2	97.6
109	69	0.2	97.7
110	75	0.2	97.9
111	69	0.2	98.1
112	52	0.1	98.2
113	52	0.1	98.4
114	52	0.1	98.5

Table 21 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
115	71	0.2	98.7
116	62	0.2	98.8
117	32	0.1	98.9
118	35	0.1	99.0
119	37	0.1	99.1
120	17	0.0	99.1
121	35	0.1	99.2
122	24	0.1	99.3
123	36	0.1	99.4
124	12	0.0	99.4
125	29	0.1	99.5
126	21	0.1	99.5
127	17	0.0	99.6
128	38	0.1	99.7
129	12	0.0	99.7
130	10	0.0	99.7
131	5	0.0	99.7
132	21	0.1	99.8
133	5	0.0	99.8
134	14	0.0	99.8
135	6	0.0	99.8
136	3	0.0	99.8
137	11	0.0	99.9
138	2	0.0	99.9
139	10	0.0	99.9
141	1	0.0	99.9
142	3	0.0	99.9
144	4	0.0	99.9
145	8	0.0	99.9
146	1	0.0	99.9
147	4	0.0	100.0
149	4	0.0	100.0
151	4	0.0	100.0
153	1	0.0	100.0
156	2	0.0	100.0
160	4	0.0	100.0
161	2	0.0	100.0
167	2	0.0	100.0
TOTAL	40114	100.0	

Table 22. Frequency of carapace length observations by number, percent, and cumulative percent for the Cape Ann region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
51	1	0.0	0.0
58	1	0.0	0.0
59	1	0.0	0.0
60	1	0.0	0.1
61	4	0.1	0.1
62	3	0.1	0.2
63	8	0.1	0.3
64	3	0.0	0.4
65	9	0.2	0.5
66	18	0.3	0.9
67	16	0.3	1.1
68	16	0.3	1.4
69	27	0.5	1.9
70	65	1.2	3.1
71	55	1.0	4.0
72	73	1.3	5.3
73	83	1.5	6.8
74	142	2.5	9.3
75	219	3.9	13.2
76	317	5.6	18.8
77	358	6.3	25.2
78	505	9.0	34.1
79	551	9.8	43.9
80	902	16.0	59.9
81	147	2.6	62.5
82	140	2.5	65.0
83	130	2.3	67.3
84	163	2.9	70.2
85	161	2.9	73.0
86	179	3.2	76.2
87	182	3.2	79.4
88	180	3.2	82.6
89	161	2.9	85.5
90	133	2.4	87.8

Table 22 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
91	161	2.9	90.7
92	123	2.2	92.9
93	101	1.8	94.7
94	53	0.9	95.6
95	30	0.5	96.1
96	22	0.4	96.5
97	22	0.4	96.9
98	16	0.3	97.2
99	20	0.3	97.5
100	12	0.2	97.8
101	20	0.4	98.1
102	10	0.2	98.3
103	7	0.1	98.4
104	6	0.1	98.5
105	11	0.2	98.7
106	11	0.2	98.9
107	12	0.2	99.1
108	6	0.1	99.2
109	6	0.1	99.3
110	2	0.0	99.4
111	2	0.0	99.4
112	3	0.0	99.4
113	1	0.0	99.4
114	3	0.1	99.5
115	1	0.0	99.5
116	1	0.0	99.5
117	2	0.0	99.6
118	5	0.1	99.6
119	1	0.0	99.7
120	1	0.0	99.7
121	1	0.0	99.7
122	3	0.1	99.7
125	2	0.0	99.8
126	1	0.0	99.8
128	4	0.1	99.8
129	2	0.0	99.9
134	1	0.0	99.9
137	1	0.0	99.9
142	2	0.0	99.9
149	2	0.0	100.0
153	1	0.0	100.0
TOTAL	5641	100.0	

Table 23. Frequency of carapace length observations by number, percent, and cumulative percent for the Beverly-Salem region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
30	1	0.0	0.0
34	1	0.0	0.0
38	1	0.0	0.0
40	1	0.0	0.0
41	1	0.0	0.1
42	1	0.0	0.1
44	1	0.0	0.1
45	4	0.0	0.1
46	3	0.0	0.2
47	1	0.0	0.2
48	2	0.0	0.2
49	3	0.0	0.2
50	5	0.1	0.3
51	10	0.1	0.4
52	10	0.1	0.6
53	14	0.2	0.7
54	21	0.3	1.0
55	31	0.4	1.4
56	30	0.4	1.8
57	24	0.3	2.1
58	30	0.4	2.5
59	49	0.6	3.1
60	42	0.5	3.7
61	53	0.7	4.4
62	49	0.6	5.0
63	59	0.8	5.8
64	72	0.9	6.7
65	76	1.0	7.7
66	69	0.9	8.6
67	108	1.4	10.0
68	121	1.6	11.6
69	126	1.6	13.2

Table 23 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
70	160	2.1	15.3
71	161	2.1	17.4
72	201	2.6	20.0
73	254	3.3	23.3
74	303	3.9	27.2
75	421	5.5	32.7
76	491	6.4	39.1
77	665	8.6	47.8
78	736	9.6	57.3
79	756	9.8	67.2
80	1078	14.0	81.2
81	98	1.3	82.5
82	144	1.9	84.3
83	151	2.0	86.3
84	130	1.7	88.0
85	160	2.1	90.1
86	147	1.9	92.0
87	113	1.5	93.5
88	131	1.7	95.2
89	118	1.5	96.7
90	89	1.2	97.9
91	45	0.6	98.4
92	38	0.5	98.9
93	24	0.3	99.3
94	15	0.2	99.4
95	13	0.2	99.6
96	7	0.1	99.7
97	5	0.1	99.8
98	3	0.0	99.8
99	2	0.0	99.8
100	3	0.0	99.9
101	2	0.0	99.9
102	5	0.1	100.0
103	2	0.0	100.0
107	1	0.0	100.0
108	1	0.0	100.0
TOTAL	7688	100.0	

Table 24. Frequency of carapace length observations by number, percent, and cumulative percent for the Boston Harbor region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
37	4	0.0	0.0
51	1	0.0	0.0
52	6	0.1	0.1
53	7	0.1	0.2
54	6	0.1	0.2
55	10	0.1	0.3
56	12	0.1	0.4
57	13	0.1	0.6
58	14	0.1	0.7
59	18	0.2	0.9
60	13	0.1	1.0
61	20	0.2	1.2
62	16	0.2	1.4
63	21	0.2	1.6
64	22	0.2	1.8
65	18	0.2	2.0
66	39	0.4	2.4
67	27	0.3	2.6
68	62	0.6	3.2
69	47	0.5	3.7
70	52	0.5	4.2
71	87	0.9	5.1
72	95	0.9	6.0
73	195	1.9	7.9
74	310	3.1	11.0
75	518	5.1	16.1
76	810	8.0	24.1
77	998	9.9	34.0
78	1148	11.3	45.3
79	1344	13.3	58.6
80	1836	18.1	76.7
81	227	2.2	79.0
82	230	2.3	81.2
83	202	2.0	83.2
84	210	2.1	85.3
85	220	2.2	87.5
86	188	1.9	89.3
87	195	1.9	91.3
88	201	2.0	93.2

Table 24 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
89	187	1.8	95.1
90	139	1.4	96.5
91	126	1.2	97.7
92	73	0.7	98.4
93	60	0.6	99.0
94	32	0.3	99.3
95	15	0.2	99.5
96	14	0.1	99.6
97	4	0.0	99.7
98	3	0.0	99.7
99	6	0.1	99.7
100	2	0.0	99.8
101	4	0.0	99.8
102	2	0.0	99.8
103	3	0.0	99.8
104	1	0.0	99.8
105	2	0.0	99.9
106	1	0.0	99.9
107	2	0.0	99.9
108	1	0.0	99.9
109	5	0.0	99.9
110	5	0.1	100.0
TOTAL	10125	100.0	

Table 25. Frequency of carapace length observations by number, percent, and cumulative percent for the Cape Cod Bay region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
29	1	0.0	0.0
32	1	0.0	0.0
36	1	0.0	0.0
37	2	0.0	0.1
40	2	0.0	0.1
41	1	0.0	0.1
42	3	0.0	0.1
43	1	0.0	0.1
44	1	0.0	0.1
45	1	0.0	0.1
46	3	0.0	0.2
47	3	0.0	0.2
48	1	0.0	0.2
49	1	0.0	0.3
50	3	0.0	0.3
51	2	0.0	0.3
52	9	0.1	0.4
53	9	0.1	0.6
54	10	0.1	0.7
55	12	0.2	0.8
56	8	0.1	1.0
57	9	0.1	1.1
58	12	0.2	1.2
59	13	0.2	1.4
60	19	0.3	1.6
61	23	0.3	2.0
62	25	0.3	2.3
63	33	0.4	2.7
64	26	0.3	3.0
65	39	0.5	3.6
66	27	0.3	3.9
67	46	0.6	4.5
68	50	0.6	5.1
69	51	0.7	5.8
70	79	1.0	6.8
71	74	1.0	7.8
72	117	1.5	9.3

Table 25 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
73	107	1.4	10.7
74	203	2.6	13.4
75	308	4.0	17.4
76	433	5.6	23.0
77	585	7.6	30.6
78	660	8.6	39.2
79	789	10.3	49.5
80	1240	16.1	65.6
81	327	4.3	69.9
82	272	3.5	73.4
83	255	3.3	76.7
84	215	2.8	79.5
85	223	2.9	82.4
86	223	2.9	85.3
87	201	2.6	87.9
88	190	2.5	90.4
89	167	2.2	92.6
90	136	1.8	94.4
91	102	1.3	95.7
92	108	1.4	97.1
93	64	0.8	97.9
94	35	0.5	98.4
95	35	0.5	98.8
96	9	0.1	99.0
97	11	0.1	99.1
98	10	0.1	99.2
99	7	0.1	99.3
100	2	0.0	99.3
101	4	0.1	99.4
102	3	0.0	99.4
103	8	0.1	99.5
104	5	0.1	99.6
105	3	0.0	99.6
106	5	0.1	99.7
107	5	0.1	99.8
108	4	0.1	99.8
109	1	0.0	99.9
110	4	0.0	99.9
112	2	0.0	99.9
114	1	0.0	99.9
115	1	0.0	100.0
118	1	0.0	100.0
119	0	0.0	100.0
127	1	0.0	100.0
TOTAL	7684	100.0	

Table 26. Frequency of carapace length observations by number, percent, and cumulative percent for the Outer Cape Cod region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
41	3	0.2	0.2
45	1	0.0	0.2
46	3	0.2	0.4
56	5	0.3	0.7
57	4	0.2	0.9
60	2	0.1	1.0
61	1	0.0	1.1
62	1	0.1	1.1
63	1	0.0	1.2
64	1	0.1	1.3
65	3	0.2	1.4
66	3	0.2	1.6
67	1	0.1	1.7
68	6	0.3	2.0
69	1	0.0	2.0
70	3	0.1	2.2
71	5	0.3	2.4
72	9	0.5	3.0
73	8	0.4	3.4
74	9	0.5	3.9
75	13	0.7	4.6
76	21	1.1	5.7
77	17	0.9	6.6
78	48	2.6	9.1
79	44	2.4	11.5
80	80	4.3	15.8
81	27	1.5	17.2
82	34	1.8	19.1
83	52	2.8	21.8
84	25	1.4	23.2
85	51	2.7	25.9
86	67	3.6	29.5
87	54	2.9	32.4
88	70	3.8	36.1
89	62	3.3	39.5

Table 26 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
90	82	4.4	43.8
91	78	4.2	48.0
92	54	2.9	50.9
93	58	3.1	54.0
94	53	2.9	56.9
95	41	2.2	59.0
96	39	2.1	61.1
97	42	2.3	63.4
98	26	1.4	64.8
99	35	1.9	66.6
100	30	1.6	68.2
101	36	1.9	70.1
102	41	2.2	72.3
103	42	2.2	74.6
104	39	2.1	76.6
105	30	1.6	78.2
106	22	1.2	79.4
107	26	1.4	80.8
108	26	1.4	82.2
109	22	1.2	83.4
110	23	1.2	84.6
111	25	1.3	86.0
112	17	0.9	86.9
113	19	1.0	87.9
114	17	0.9	88.8
115	25	1.3	90.1
116	22	1.2	91.3
117	11	0.6	91.9
118	11	0.6	92.5
119	13	0.7	93.2
120	6	0.3	93.5
121	12	0.7	94.2
122	8	0.4	94.6
123	13	0.7	95.3
124	4	0.2	95.5
125	10	0.5	96.1
126	7	0.4	96.5
127	5	0.3	96.7
128	13	0.7	97.4
129	4	0.2	97.7
130	4	0.2	97.8
131	2	0.1	97.9
132	8	0.4	98.4
133	2	0.1	98.5

Table 26 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
134	5	0.3	98.7
135	2	0.1	98.8
136	1	0.1	98.9
137	4	0.2	99.1
138	1	0.0	99.1
139	4	0.2	99.3
141	1	0.0	99.4
142	1	0.0	99.4
144	1	0.1	99.5
145	3	0.1	99.6
146	1	0.0	99.6
147	1	0.1	99.7
149	1	0.1	99.8
151	1	0.1	99.8
156	1	0.0	99.9
160	1	0.1	99.9
161	1	0.0	100.0
167	1	0.0	100.0
TOTAL	1868	100.0	

Table 27. Frequency of carapace length observations by number, percent, and cumulative percent for the Buzzards Bay region, Massachusetts coastal waters, 1986.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
35	1	0.0	0.0
38	2	0.0	0.0
45	1	0.0	0.0
53	1	0.0	0.1
54	3	0.0	0.1
55	1	0.0	0.1
56	3	0.0	0.1
57	5	0.1	0.2
58	5	0.1	0.3
59	3	0.0	0.3
60	14	0.2	0.5
61	11	0.2	0.7
62	13	0.2	0.9
63	16	0.2	1.1
64	17	0.2	1.3
65	33	0.5	1.8
66	45	0.6	2.4
67	60	0.8	3.3
68	71	1.0	4.3
69	93	1.3	5.6
70	128	1.8	7.4
71	145	2.0	9.4
72	177	2.5	11.9
73	277	3.9	15.8
74	322	4.5	20.3
75	369	5.2	25.5
76	513	7.2	32.7
77	615	8.7	41.4
78	719	10.1	51.5
79	669	9.4	60.9
80	982	13.8	74.7
81	162	2.3	77.0
82	235	3.3	80.3
83	238	3.3	83.6
84	226	3.2	86.8
85	205	2.9	89.7

Table 27 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
86	179	2.5	92.2
87	138	1.9	94.2
88	110	1.5	95.7
89	104	1.5	97.2
90	77	1.1	98.3
91	30	0.4	98.7
92	26	0.4	99.1
93	14	0.2	99.3
94	14	0.2	99.5
95	10	0.1	99.6
96	5	0.1	99.7
97	5	0.1	99.8
98	6	0.1	99.8
99	3	0.0	99.9
101	4	0.0	99.9
104	2	0.0	99.9
106	1	0.0	99.9
107	4	0.1	100.0
TOTAL	7108	100.0	

Table 28. Mean carapace length (mm) of all ovigerous female American lobster by state and region sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	88.5	87.6	88.6	87.4	87.9	88.1
Cape Ann	109.0	100.3	94.3	90.5	93.8	95.0
Beverly-Salem	80.5	84.5	85.8	83.5	85.9	83.5
Boston Harbor	--	--	--	82.1	84.0	81.3
Cape Cod Bay	86.4	83.8	85.5	84.4	85.2	86.8
Outer Cape Cod	109.8	106.1	108.0	107.1	106.9	107.3
Buzzards Bay	78.1	79.6	81.6	83.0	80.1	79.4

Table 29. Percent of ovigerous female American lobster ≥ 81 mm carapace length, by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	53.8	58.8	65.0	61.4	57.7	53.8
	(429)*	(525)	(1294)	(885)	(1294)	(1937)
Cape Ann	100.0	90.0	89.3	69.9	79.0	78.8
	(2)	(6)	(43)	(36)	(125)	(134)
Beverly-Salem	27.3	68.6	62.5	50.0	59.1	50.0
	(14)	(24)	(11)	(3)	(80)	(49)
Boston Harbor	--	--	--	60.6	33.8	28.5
				(40)	(60)	(134)
Cape Cod Bay	61.0	42.7	57.2	58.1	54.3	53.5
	(192)	(154)	(127)	(81)	(111)	(71)
Outer Cape Cod	100.0	99.6	99.7	99.1	99.9	99.1
	(46)	(192)	(476)	(205)	(291)	(288)
Buzzards Bay	15.4	30.1	45.7	41.2	38.6	26.9
	(175)	(149)	(637)	(520)	(627)	(1261)

*(N)

Table 30. Short and long term effects of increasing the minimum legal size of Massachusetts lobster from 81 to 82 mm. Predictions made from analysis of May-November, 1986 length frequency data by the Hancock method.

Region	Cape Ann	Beverly Salem	Boston Harbor	Cape Cod Bay	Outer Cape Cod	Buzzards Bay	Regions Combined
Short Term Loss							
%#	-6.48	-6.77	-9.62	-12.39	-1.71	-9.01	-7.72
% Wt.	-4.79	-5.56	-7.84	-10.09	-0.89	-7.65	-6.93
Long Term Gain							
F* =	1.22	1.93	1.80	1.70	0.47	2.11	1.27
%#	-1.40	-1.20	-1.80	-2.40	-0.60	-1.60	-1.70
% Wt.	0.90	1.30	1.80	2.20	0.00	1.60	1.00
F** =	1.88	3.45	2.45	2.68	0.36	3.56	1.64
%#	-1.20	-1.00	-1.60	-2.00	-0.70	-1.40	-1.50
% Wt.	1.10	1.60	2.00	2.60	-0.10	1.90	1.20

*Derived from Cohort Analysis

**Derived from Regression Analysis (Z - 0.15 = F)

Table 31. Short and long term effects of increasing the minimum legal size of Massachusetts lobster from 81 to 82 mm. Predictions made from analysis of November, 1986 length frequency data by the Hancock method.

Region	Cape Ann	Beverly Salem	Boston Harbor	Cape Cod Bay	Outer Cape Cod	Buzzards Bay	Regions Combined
Short Term Loss							
%#	-5.81	-5.07	-6.33	-4.67	-1.61	-8.66	-5.22
% Wt.	-4.38	-4.22	-5.09	-3.83	-0.81	-7.45	-3.94
Long Term Gain							
F* =	1.32	2.27	1.75	1.81	0.52	2.23	1.28
%#	-1.20	-0.90	-1.20	-0.90	-0.50	-1.50	-1.10
% Wt.	0.80	1.10	1.20	0.90	0.00	1.60	0.70
F** =	1.71	2.53	2.51	2.33	0.09	2.80	1.47
%#	-1.10	-0.80	-1.10	-0.80	-1.10	-1.40	-1.10
% Wt.	1.00	1.10	1.30	1.00	-0.50	1.70	0.80

*Derived from Cohort Analysis

**Derived from Regression Analysis (Z - 0.15 = F)

Table 32. Percent of male American lobster, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	42.0	41.0	41.0	38.0	41.9	40.2
Cape Ann	42.0	46.0	39.0	35.0	41.2	40.7
Beverly-Salem	44.0	41.0	51.0	50.0	42.2	50.7
Boston Harbor	--	--	--	40.0	48.2	40.8
Cape Cod Bay	39.0	36.0	36.0	36.0	40.6	40.3
Outer Cape Cod	44.0	46.0	44.0	41.0	45.9	38.1
Buzzards Bay	43.0	47.0	36.0	34.0	36.2	31.9

Table 33. Percent of male American lobster $\geq$ 81 mm, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	44.0	47.0	45.0	41.0	45.6	42.8
Cape Ann	47.0	51.0	42.0	36.0	44.8	43.6
Beverly-Salem	47.0	49.0	62.0	59.0	44.3	57.4
Boston Harbor	--	--	—	45.0	57.6	48.2
Cape Cod Bay	43.0	45.0	45.0	43.0	47.2	48.6
Outer Cape Cod	43.0	44.0	41.0	41.0	45.3	36.8
Buzzards Bay	44.0	48.0	35.0	31.0	32.7	25.9

Table 34. Percent of male American lobster < 81 mm, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	40.0	37.0	38.0	36.0	39.6	38.7
Cape Ann	24.0	30.0	36.0	35.0	38.8	38.8
Beverly-Salem	43.0	37.0	47.0	47.0	41.6	49.1
Boston Harbor	--	--	--	38.0	44.6	38.5
Cape Cod Bay	37.0	33.0	31.0	32.0	37.3	36.0
Outer Cape Cod	53.0	54.0	55.0	44.0	49.3	44.5
Buzzards Bay	42.0	47.0	37.0	35.0	37.8	33.9

Table 35. Cull rate (percent) by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	10.0	10.8	10.7	14.8	18.1	20.9
Cape Ann	10.0	9.8	10.5	11.5	23.9	25.3
Beverly-Salem	8.3	8.6	10.2	20.9	23.0	30.0
Boston Harbor	--	–	--	13.3	19.3	19.1
Cape Cod Bay	11.1	10.7	10.9	15.6	18.3	21.6
Outer Cape Cod	5.7	11.3	8.9	13.0	13.4	16.1
Buzzards Bay	13.5	14.7	12.4	12.4	13.4	14.6

Table 36. Cull rate (percent) by state and region for American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	8.1	9.7	9.2	12.7	14.8	17.0
Cape Ann	10.7	9.6	7.5	10.4	19.4	20.3
Beverly-Salem	4.3	7.7	7.4	15.5	19.3	22.1
Boston Harbor	--	--	--	10.1	16.2	15.8
Cape Cod Bay	9.3	9.3	10.0	13.2	14.5	18.1
Outer Cape Cod	5.3	10.3	8.1	13.3	12.5	14.9
Buzzards Bay	16.1	13.2	12.7	12.3	13.8	13.6

Table 37. Cull rate (percent) by state and region for marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	8.2	9.9	9.2	15.0	16.2	17.6
Cape Ann	10.8	9.8	7.3	11.5	20.9	20.7
Beverly-Salem	4.4	8.0	7.4	20.9	18.5	22.2
Boston Harbor	--	--	--	13.3	16.2	15.7
Cape Cod Bay	9.3	9.3	10.0	15.6	15.9	18.2
Outer Cape Cod	5.3	10.9	8.6	14.2	12.9	16.8
Buzzards Bay	16.9	13.1	12.3	12.5	15.4	14.1

Table 38. Cull rate (percent) by state and region for American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	11.2	11.5	11.6	16.1	20.2	23.2
Cape Ann	8.0	10.6	12.6	12.2	26.9	28.7
Beverly-Salem	10.0	9.0	11.2	22.3	24.0	31.8
Boston Harbor	--	--	--	14.5	20.5	20.0
Cape Cod Bay	11.9	11.3	11.4	17.0	20.2	23.4
Outer Cape Cod	7.8	17.9	13.5	11.7	18.6	22.8
Buzzards Bay	12.7	15.2	12.2	12.4	13.3	14.9

Table 39. Percent trap mortality by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.15	0.04	0.22	0.15	0.18	0.20
Cape Ann	0.00	0.00	0.09	0.27	0.03	0.16
Beverly-Salem	0.00	0.00	0.00	0.00	0.04	0.22
Boston Harbor	--	--	--	0.00	0.03	0.03
Cape Cod Bay	0.00	0.02	0.03	0.00	0.00	0.02
Outer Cape Cod	0.46	0.22	0.23	0.48	0.40	0.85
Buzzards Bay	0.62	0.00	1.13	0.43	0.76	0.25

Table 40. Percent trap mortality by state and region for American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.16	0.04	0.26	0.20	0.23	0.29
Cape Ann	0.00	0.00	0.00	0.10	0.03	0.22
Beverly-Salem	0.00	0.00	0.00	0.00	0.00	0.49
Boston Harbor	--	—	--	0.00	0.04	0.04
Cape Cod Bay	0.00	0.00	0.00	0.00	0.00	0.00
Outer Cape Cod	0.39	0.16	0.18	0.51	0.36	0.71
Buzzards Bay	0.62	0.00	1.46	0.40	0.96	0.28

Table 41. Percent trap mortality by state and region for American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1986.

	1981	1982	1983	1984	1985	1986
State	0.15	0.03	0.20	0.12	0.15	0.15
Cape Ann	0.00	0.00	0.14	0.39	0.02	0.12
Beverly-Salem	0.00	0.00	0.00	0.00	0.05	0.16
Boston Harbor	--	--	--	0.00	0.02	0.02
Cape Cod Bay	0.00	0.03	0.05	0.00	0.00	0.03
Outer Cape Cod	0.87	0.65	0.50	0.31	0.62	1.62
Buzzards Bay	0.62	0.00	0.94	0.45	0.68	0.24